On-the-Fly Bridge Profile Sensor Provides Data for Overheight Permitting

RESULTS: AHMCT researchers have developed a prototype system for on-the-fly bridge profile sensing. The vehicle-based sensing system uses a scanning laser to measure range and reflected power from the bridge and the roadway. The operation occurs at highway speed, i.e. with no fixed or rolling closure. The laser data is analyzed by custom software to determine bridge height measurements, as well as lane widths and other horizontal dimensions. The software includes a user interface for interactive fine-tuning of the results. These dimensions can then be used to update a two-dimensional profile of the bridge and the corresponding databases in support of overheight vehicle permitting.

Why We Are Pursuing This Research

Accurate bridge-height clearance information for overheight route planning is critically important to the nation's economy. Collecting this data can be dangerous or can cause congestion. The current system allows on-the-fly sensing of two-dimensional bridge profiles from a moving vehicle, and subsequent data analysis and extraction to support maintaining these vital database and permitting systems.

What We Are Doing

AHMCT researchers have developed an architecture and prototype system to determine bridge structure two-dimensional profiles for use in overheight permitting and routing. The system is based on a vehicle-mounted scanning laser range-finder. Reflected range and power measurements support post-processing by custom software to identify key features, and allow estimation of bridge height over each lane stripe, as well as horizontal clearance information including lane and road widths. The sensing can be done at highway speed, i.e. with no fixed or rolling closure. The structure and roadway elements are sensed entirely from within the moving vehicle, so that workers are not exposed to high-speed traffic.

The scanning laser (block diagram and hardware shown in Fig. 1, laser detail in Fig. 2), with no vehicle motion, provides a two-dimensional slice of range and reflected power. The vehicle provides the forward motion, resulting in a helical scan of the bridge structure. The collected data provides a detailed 3-D world model of the bridge underdeck and the surrounding roadway. A digital still camera acquires a coordinated image of the overall bridge profile for future identification and verification purposes. The entire sensing operation is coordinated with the vehicle speed, and acquisition can be manually triggered by the operator, or coordinated with GPS/GIS.

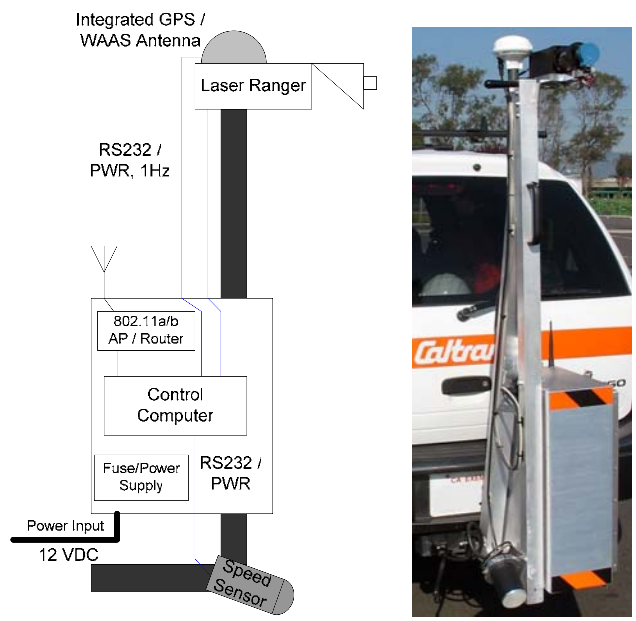

Figure 1 – Bridge profile sensing hardware

Custom software post-processes the collected data, and identifies key features. The process begins with a variety of filtering operations to reduce noise while exploiting known properties of bridges and roadways. The helical scan data is converted into Cartesian coordinates, yielding a full 3-D point model of the bridge underdeck and surrounding roadway. This model can later be used for visualization and other applications, in addition to the profiling operation. The program identifies key lane boundaries and road edges and curbs—critical of course for horizontal dimensions, but also essential as federal standards mandate that bridge heights shall be measured above lane boundaries. From these identified features, the software then estimates the clearance heights above each lane stripe, and also provides the horizontal dimensions for lane widths, distance to curbs, distance to bents, etc. This information gives a full two-dimensional profile of the bridge.

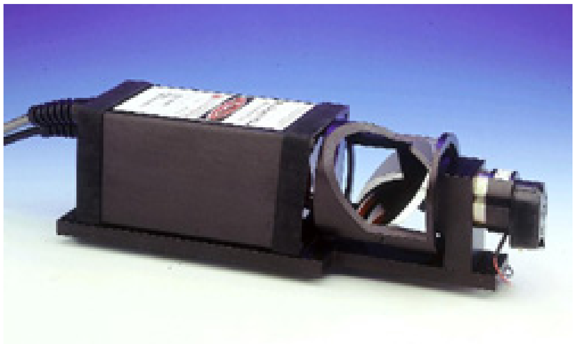

Figure 2 – Scanning Laser range finder for profile sensing

The software allows for interactive operation so that human perception, experience, and intelligence can improve the overall results. The interface helps the analyst to iterate on feature identification and measurement operations until the results reflect the best combination of automatic sensing and processing mixed with human strengths.

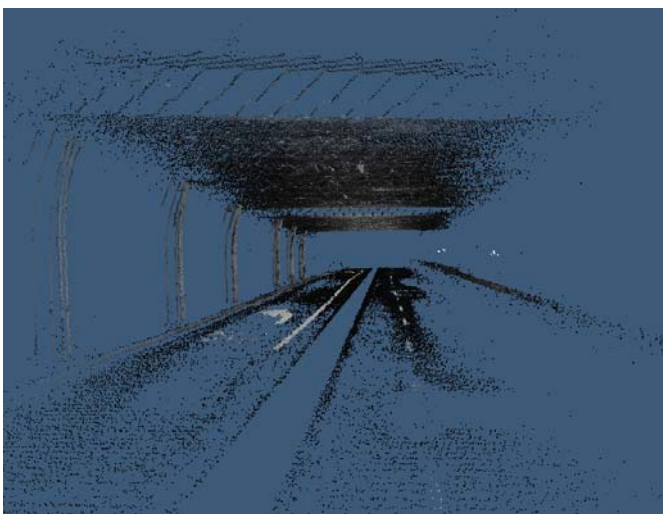

Figure 3 – Sample bridge scan data before processing

The results of the automatic and human interactive feature and dimension identification are then output in a standard format based on current DOT practices. For example, the results can be output in a standard two-dimensional profile drawing, matching the output provided by current structural inspections. As such, the format is well-matched with current practices, and will require no organizational changes or re-training. However, as the data is available digitally, it is possible to support other output modes, as well as direct computer interaction with other systems. With full confidence in the system and human interaction at the stage of feature identification and dimension extraction, it is conceivable to provide automatic update of the relevant databases.

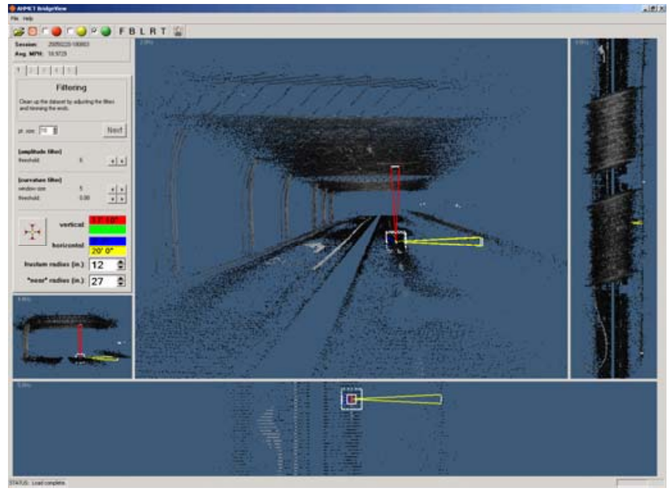

Figure 4 – Sample screen from visualization software, illustrating tool for manual height and width dimension ID

Current Status

The prototype system was field-tested by Caltrans Structures Maintenance personnel in early 2005. Initial test results are very positive, and AHMCT researchers are making final updates to the system hardware and software. The system is now ready for a follow-up phase of intensive field-testing, further detailed iterations between the end users and the development team, and transition to a fully deployable unit. Based on current results, this on-the-fly bridge profile measurement system, combined with the user interface to support interactive feature identification and measurement validation, will greatly enhance the accuracy, safety and efficiency of structure profile measurements, and will strongly benefit overheight permitting and routing operations.

For Additional Information

Arvern Lofton♣	(916) 324-2295	Arvern_Lofton@dot.ca.gov
Ty A. Lasky♥	(530) 752-6366	talasky@ucdavis.edu
Bahram Ravani♠	(530) 754-6130	bravani@ucdavis.edu
Kin S. Yen♦	(530) 754-7401	ksyen@ucdavis.edu

Visit us at www.ahmct.ucdavis.edu

♣ Caltrans Project Manager
♥ Principal investigator for this project
♠ Co-Prinicipal investigator for this project
♦ Primary contact for this project